Long-Range (5-10 Day) Swell Wave Forecasts

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LONG-TERM GOAL

Our long-term goal is to contribute to the accurate prediction of swell wave generation, and propagation across ocean basins through the combined use of measurements and models.

OBJECTIVES

Our primary objectives are to develop methodologies to extract swell wave height and directional information from operational global wave models and use this data in concert with satellite and in situ measurements to make 5-10 day swell forecasts. A secondary objective is to use the resulting methods to contribute to future improvements in global wave model generation and long distance propagation algorithms.

APPROACH

The operational deep water wave forecasts model (WAM) presently used by Fleet Numerical provides wave forecasts (frequency-directional wave spectra) with a global resolution of 1 degree in latitude in longitude. The wave forecasts extend out to 5 days, which is the present forecast range of the input NOGAPS wind fields. However, it can take 10 days or more for generated swell waves to propagate across large ocean basins. Therefore, the global wave output contains additional long-range swell information in the form of long period wave energy that has been generated within in the model along great circle paths that extend across large reaches of ocean.

Our approach is to make long-range swell forecasts on a site-by-site basis. Great circle paths for all directions are traced from the forecast site to define its relationship to the global wave model output spectra as a function of wave frequency, direction, and time lag. In other words, the forecast swell spectrum, for a specific location and forecast hour, is the sum of partial contributions from global wave model output spectra at more distant locations as defined by the great circle paths and group propagation speed at each swell frequency. Satellite and in situ measurements of wave energy along great circle routes to the forecast sites will be assimilated using methods analogous to those presently used to enhance short-range WAM model predictions.

WORK COMPLETED

An experimental operational long-range swell forecast model has been implemented for a deep water location offshore of Monterey CA (Figure 1.). Real-time output from the U.S. Navy's global wave forecast model is used to update the swell forecast model every 12 hours. The forecasts are routinely compared to measurements from NOAA buoy 46042 off Monterey and/or a Datawell Directional Waverider buoy offshore of Pt. Reyes, CA.

It is well known that the global WAM model often underpredicts long period swell wave energy in the Pacific Ocean. However, it not well understood whether this underprediction is primarily owing to the undergeneration of swell energy by the model or excessive directional diffusion (spreading) of swell as it propagates long distances though the WAM model domain using a first-order finite-difference algorithm. The alternative extraction of swell energy along great circle routes, used in the long-range forecasts, has provided some insight into this question. Specifically, the underprediction of long period swell is also commonly observed in model-data comparisons at the Monterey site using the great circle method. This suggest that the WAM model undergenerates long period energy in the source region of the swell.

Finally, we have found some discrepancies between the propagation of wave energy along great circle routes in the long-range forecast model and the propagation of energy in the WAM model by finite difference methods. The comparisons suggest that wave energy in the WAM model does not always adhere to great circle routes. The underlying cause of these differences is presently being studied.

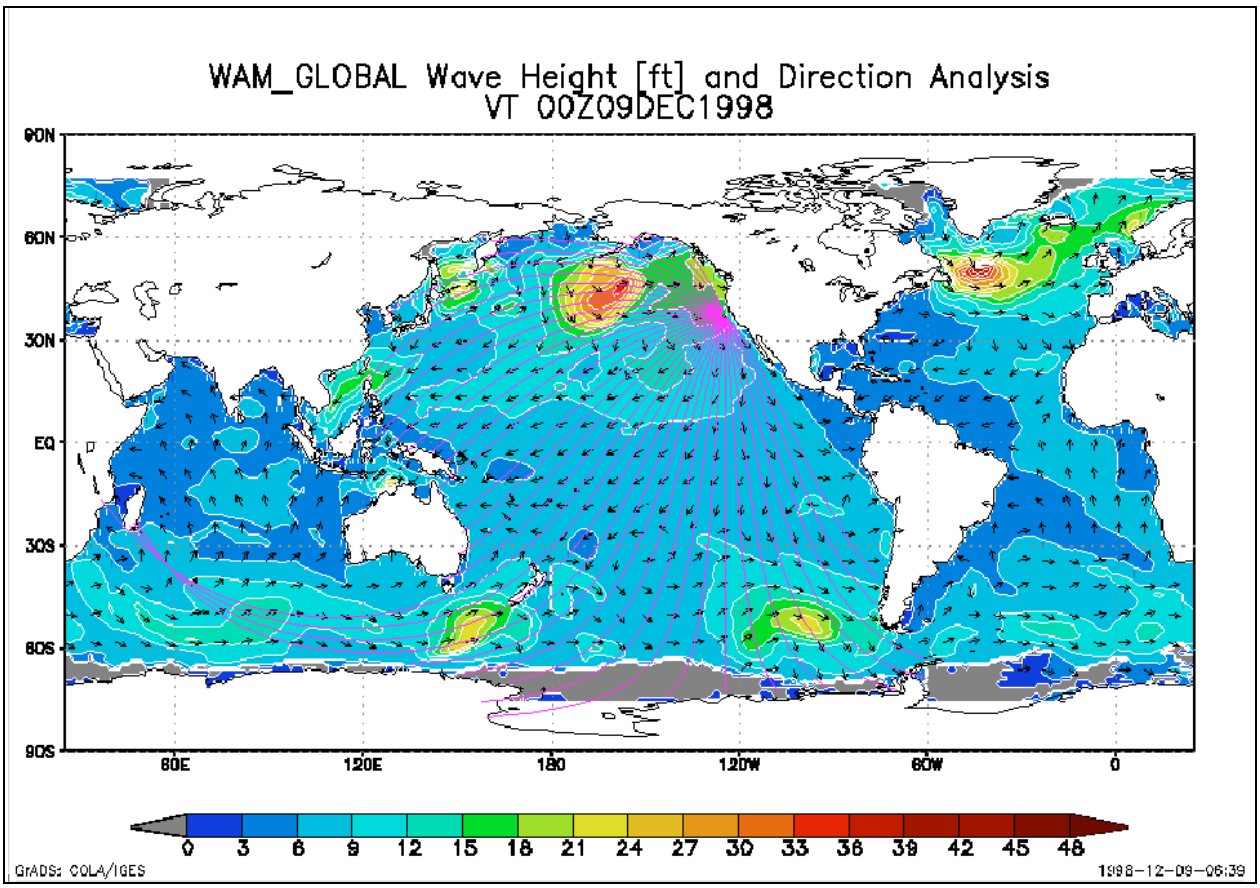

Figure 1. Example of FNMOC WAM model global wave height forecast, overlaid with great circle routes (purple lines) to a site offshore of Monterey, CA. The present FNMOC 5 day forecasts for Monterey only make use of swell energy present in the Northeast Pacific. The great circle paths are used to extract more distant WAM model data and extend the swell forecasts beyond 5 days (e.g. it takes approximately 10 days for swell to reach Monterey from storms off New Zealand).

RESULTS

Preliminary results from the long-range swell forecast model indicate that swell predictions can be extended out as far as 10 days without loss of model accuracy. In addition, the methodology can enhance the directional accuracy of WAM model forecasts through the direct use of great circles to propagate wave energy from distant source regions to the forecast site.

IMPACT/APPLICATION

The results to date indicate that the long-range forecast model would be a useful addition to FNMOC and NAVO operational wave forecast products.

TRANSITIONS

The experimental long-range forecast model is being transitioned to NRL for further development and validation with support from the SPAWAR program. An operational product is anticipated within the next two years.

RELATED PROJECTS

1. Waves Base Enhancement (BE) program.
2. Shoaling Waves DRI field experiment.
3. The Coastal Data Information Program, USACE and CA Dept. of Boating and Waterways
4. Joint work with Paul Wittmann, FNMOC-Monterey
5. Joint SPAWAR work with Larry Hsu, NRL-Stennis